Open Pit Mining
Extraction and Ore Transportation Methods

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ABSTRACT

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Keywords: transportation, hoisting, open pit mining

Open pit transportation has an important role in the open pit mining business. In some cases, the transportation has a 50% slice of total operating costs. Therefore, it is important to carefully calculate the most economic transportation method for the specific case.

The ore transportation method can rarely be changed during the pit production. Large investments have been made which dictate the limits of ore production, or at least raise the total investment costs when left unused. Therefore, in the beginning of the mining project it is important to carefully calculate the economic alternatives for ore transportation.

The aim of this report is to collect the main the aspects of ore transportation methods suitable for Finnish mines. The pros and cons of the methods depend a lot on the particular case and its features. In some cases typical advantages may change to problems and on the other hand big problems may be eliminated with a certain method. For example hydraulic hoisting (if water is used as medium) may be a good choice in places where the ground water is problem, because the water is hoisted with the ore.

Cost comparison is left outside this report, for the following reasons: a) because of numerous parameters affecting the real cost of a particular method, the given cost would be correct only in one sample case b) not even average cost figures were available in many methods and c) even if they were, the trendsetting numbers may give a misleading idea of costs in different cases.

TIIVISTELMÄ

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Avainsanat: nosto, kuljetus, avolouhos, avolouhinta

Kiven kuljetus voi muodostaa jopa 50% avolouhoksen käyttökuluista. Tämän vuoksi on esiarvoisen tärkeää selvittää kulloisiinkin olosuhteisiin parhaiten sopiva menetelmä.

Monestikaan ei ole mahdollista vaihtaa nostomenetelmää toiseen tehtyjen investointien takia, tai ainakin jo tehdyt investoinnit nostavat kokonaisinvestointikustannuksia vanhojen laitteiden jäädessä käyttämättä. Tästä syystä on tärkeää kiinnittää jo suunnitteluvaiheessa riittävästi huomiota myös nostomenetelmän valintaan. Nykyisin monilla kaivoksilla noston suorittaa itsenäinen urakoitsija, jolloin sopimuksen umpeutuessa on hyvä tarkistaa tilanne myös menetelmän osalta.

Tämä raportin ensisijaisena tarkoituksena on ollut kerätä pääkohdat Suomessa kyseeseen tulevista malmin nostomenetelmistä. Menetelmien edut ja haitat riippuvat hyvin paljon kohteesta ja sen erityispiirteistä. Joissakin paikoissa yleisesti selkeät edut voivat muuttua haitoiksi ja toisaalta suuret haitat voidaan eliminoida jollakin toisella nostomenetelmällä. Esimerkkinä voi mainita hydraulisen noston (mikäli käytetään nostossa väliaineena vettä), joka runsasvetisissä kohteissa voi olla hyvinkin edullinen vaihtoehto, koska malmin kanssa samalla saadaan nostettua muuten haitallinen vesi.

Kustannusvertailu on jätetty kokonaan pois seuraavista syistä: a) koska todellisiin kustannuksiin vaikuttaa suunnaton määrä parametreja, olisivat annetut kustannukset oikeita vain tietyssä esimerkkikohteessa, b) monista menetelmistä ei ollut saatavilla edes keskimääräisiä kustannuksia ja c) suuntaa-antavienkin lukujen antaminen on katsottu voivan antaa harhaanjohtavan käsityksen todellisista kustannuksista eri kohteissa.

CONTENTS

1 INTRODUCTION

The aim of this literature study is to collect material related to transportation methods in open pit mines suitable for Finnish rock conditions. Items dealt with are technology, equipment and limitations of methods. Since the extraction method determines the particle size and in-pit primary crushing is needed in some transportation methods, extraction and crushing methods are discussed briefly. Economics has been left outside this study, because too many parameters are needed to determine at least preliminary costs.

2 EXTRACTION METHODS

Traditionally the excavation has been done in hard rocks by drilling and blasting. New methods that are more continuous have been developed. At present machinery development has reached the level where it is economical to use it in mining rocks like limestone, but harder rocks still have to be mined with conventional methods. Machines, which are not suitable for Finnish rock conditions, like BWEs, are left outside this study.

2.1 Drilling and blasting

Although many new extraction methods have been developed, the drilling and blasting method is still most used in mineral and ore mines in Finland. It has been the only economic alternative in hard rocks.

The drilling can be designed many ways, but there can be found three major groups (Figure 1):

- vertical holes
- horizontal holes
- horizontal toe holes with vertical holes

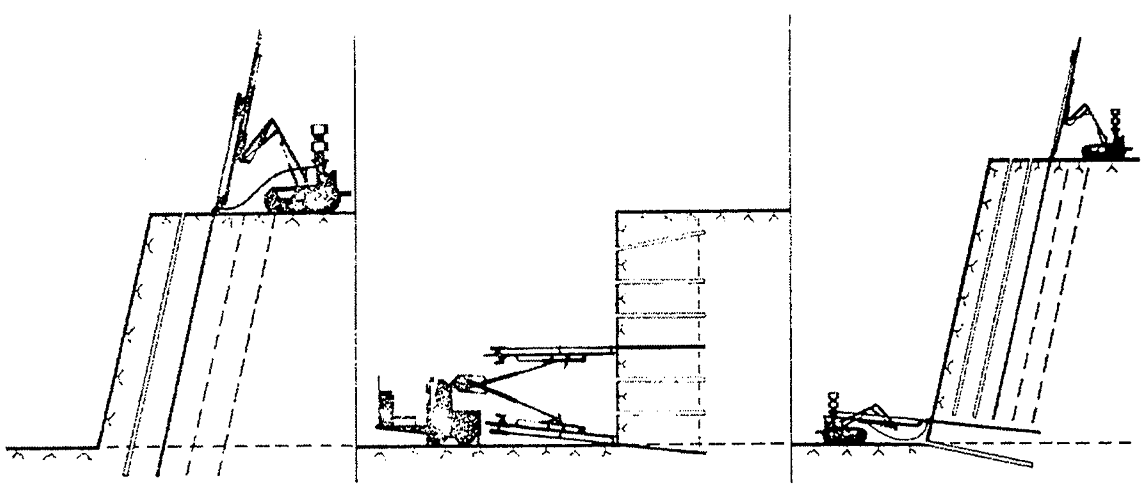

Figure 1 Three alternatives on how to drill the bench /1/.

The most common method is the vertical-holes method. The pattern and number of holes as well as bench height are designed for each pit. Also there might be differences between the rock types in the same pit. It is quite common that after the field is drilled the holes are examined to be sure that the hole is in ore. Only the holes in the ore are charged to minimize the striping ratio.

Special methods like Coyote holing have been developed from the major techniques, but they are quite extraordinary.

2.2 Continuous methods

The development of extraction methods is moving towards the more continuous, process like methods. There are many concepts available, but they are not economical in hard rocks yet.

The methods described here produce material whose granular size distribution is about 0-200 mm. This means that no in-pit crushing is needed for transportation, unless pumping is used. Extra saving are accrued from the unneeded primary crusher.

Table 1 Comparison of continuous systems /2/.

SYSTEM	MAKER	Limiting compressive strength, (MPa)	Cutting depth, (m)	Cutting speed, (m/min)	Maximum capacity, (t/h)
BWE	Takraf Voest-Alpine	25	0.2-7	n/a	1000
Milling types	Wirtgen Huron	100	0-0.6	0-25	2500
Shearing types	PWH	150	1.8-2.5	0-10	2100

2.2.1 Milling type excavators

In road construction, machines that cut old road surfaces (asphalt), so that it can be partly recycled have been used for quite some time. Recently these kinds of machines have also been tested in Finnish open pit mines for cutting soft rocks like limestone with encouraging results. Other materials which may be cut are: coal, gypsum, bauxite and materials as hard as 6 on the Mohs scale.

Similar machines are known to be constructed by two different companies, Huron Manufacturing Corporation (Figure 2, Figure 4) and Wirtgen (Figure 3, Figure 5). The main difference between these two concepts is the direction of rotation of the cutting drum.

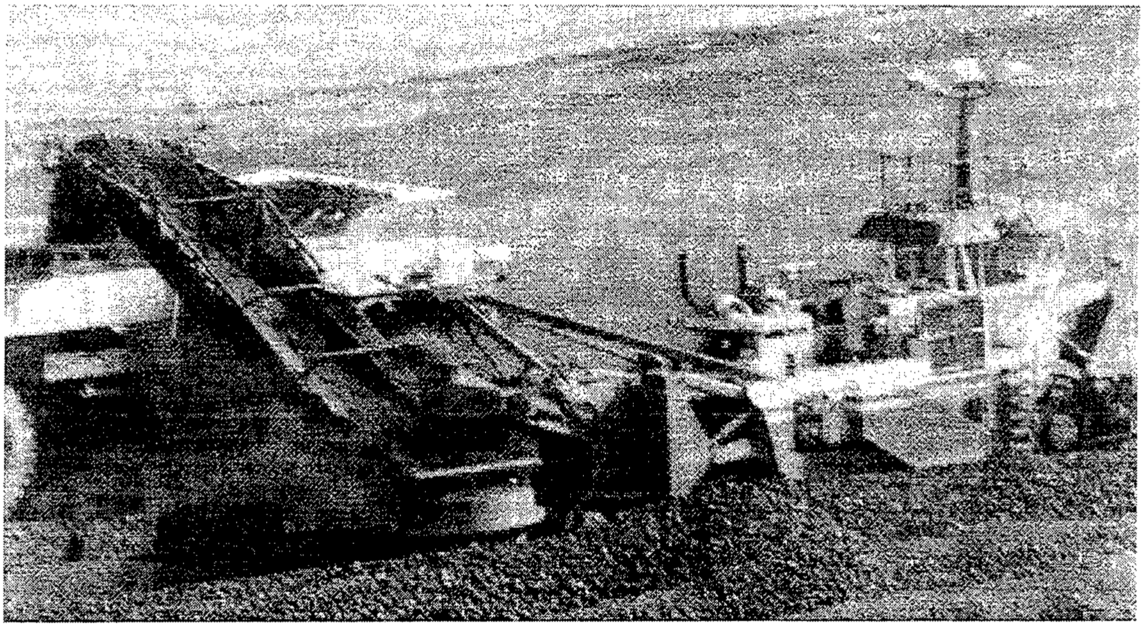

Figure 2 Huron Easi-miner Model 1224.

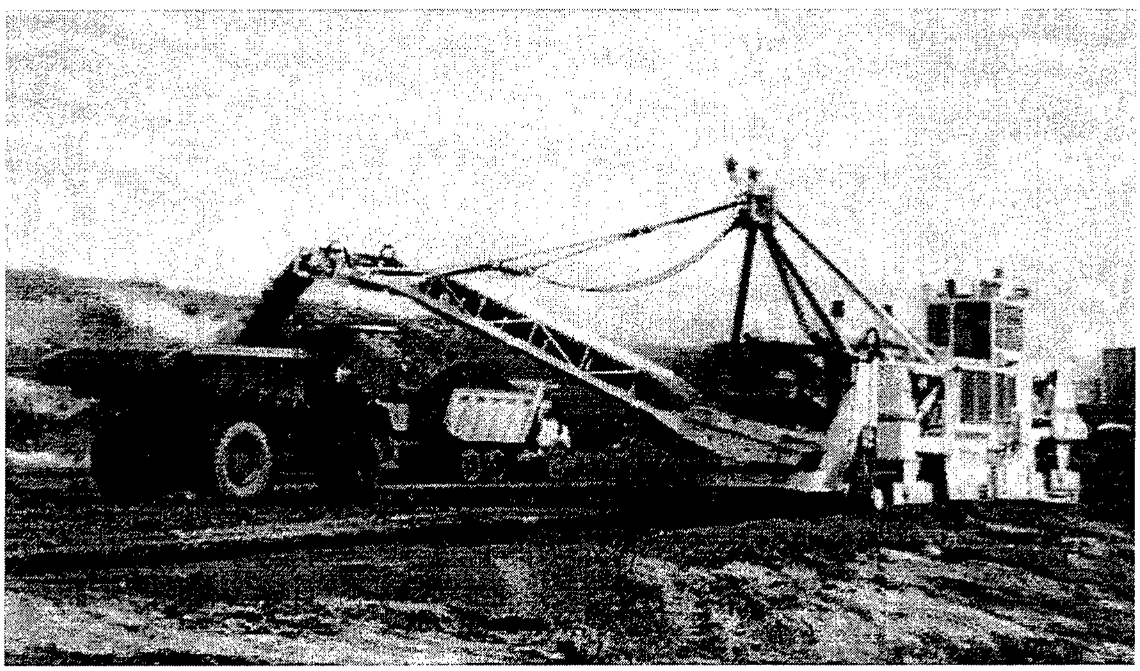

Figure 3 Wirtgen surface miner.

In both machines the cutting drum is fitted with replaceable tooth units. The teeth are arranged in an augering pattern to get maximum cutting effect and to feed excavated material to the conveyor. The rotation speed of the drum is about 60 rpm.

The production volume varies from pit to pit, depending on pit design, rock conditions and equipment size.

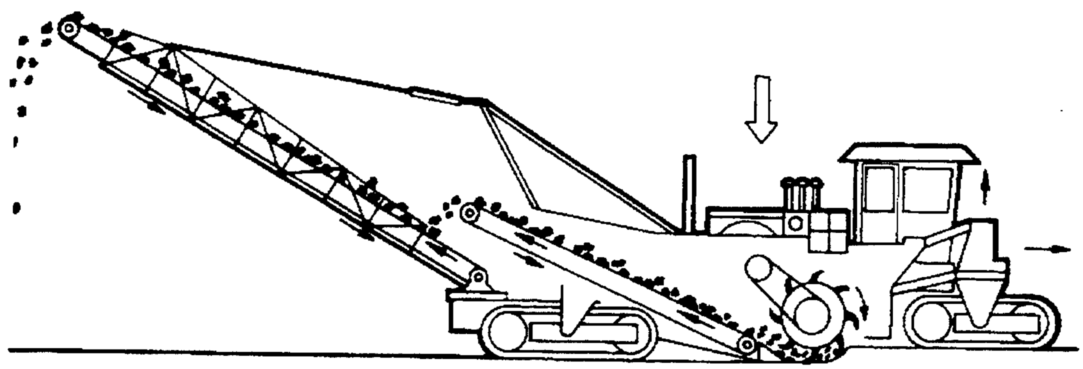

Figure 4 Principal design of the Huron Easi-Miner. See nomenclature in Figure 5.

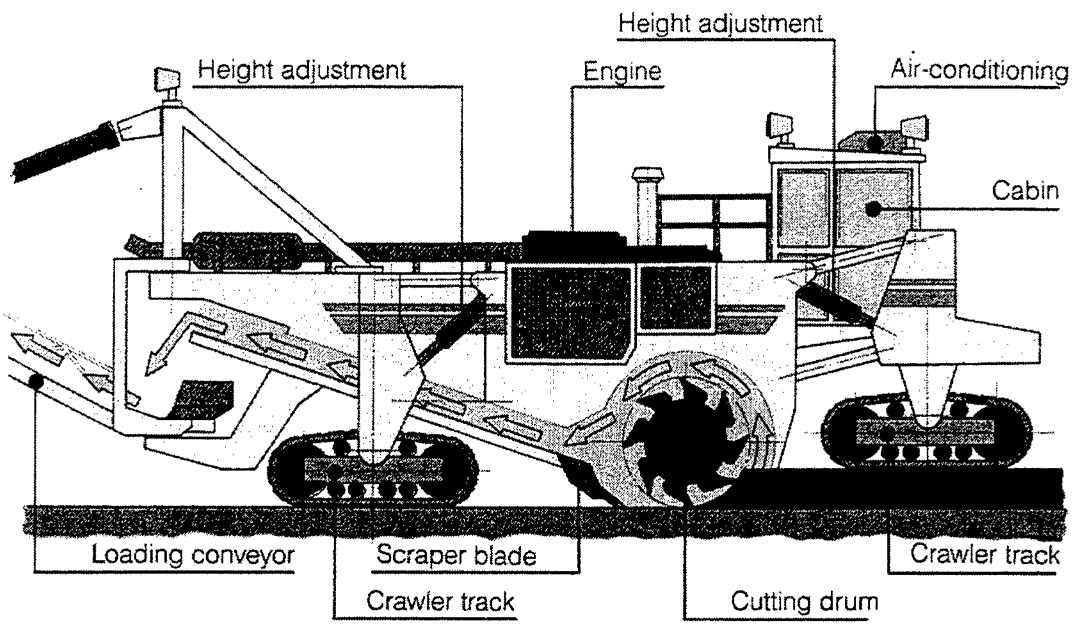

Figure 5 Principal design of the Wirtgen surface miner.

2.2.2 Shearing type excavators

The biggest difference between milling and shearing type excavators is the cut height. While milling type machines cut 5-40 cm in each cut, the shearing type excavators cut 10-550 cm with each cut.

Two similar machines are presented in this section. Both machines C-Miner (Figure 6) and Voest-Alpine (Figure 7) surface miner can cut soft rocks like limestone although the latter is designed principally for coal mining. The Voest Alpine surface miner has also been tested in a Finnish limestone pit with good results. Its performance and suitability to that specific pit was even better than the Wirtgen surface miner because the Wirtgen needs large area to work with reasonable capacity. That is not needed with the Voest-Alpine.

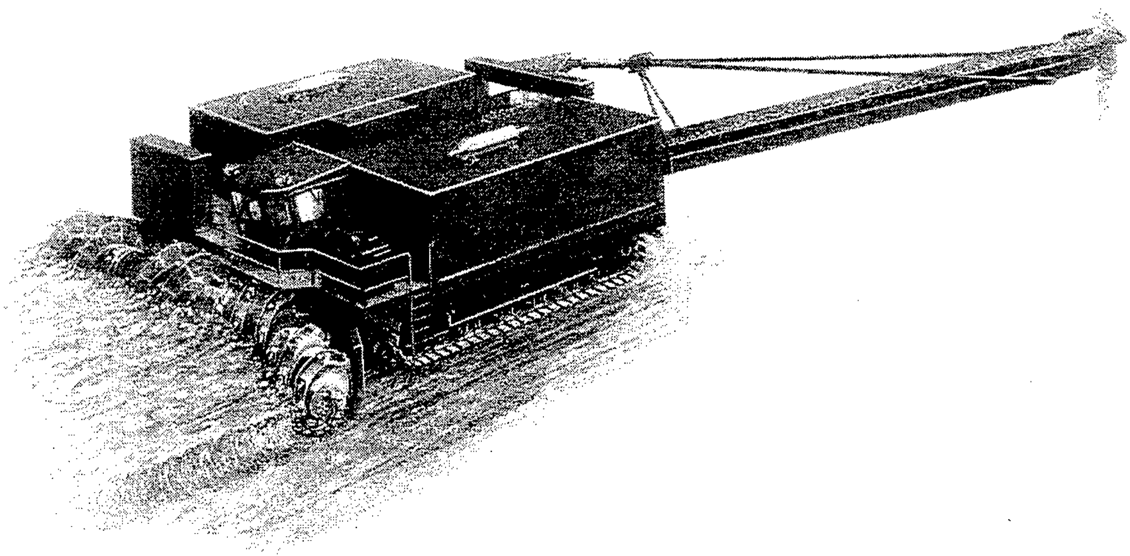

Figure 6 C-Miner in operation /3/

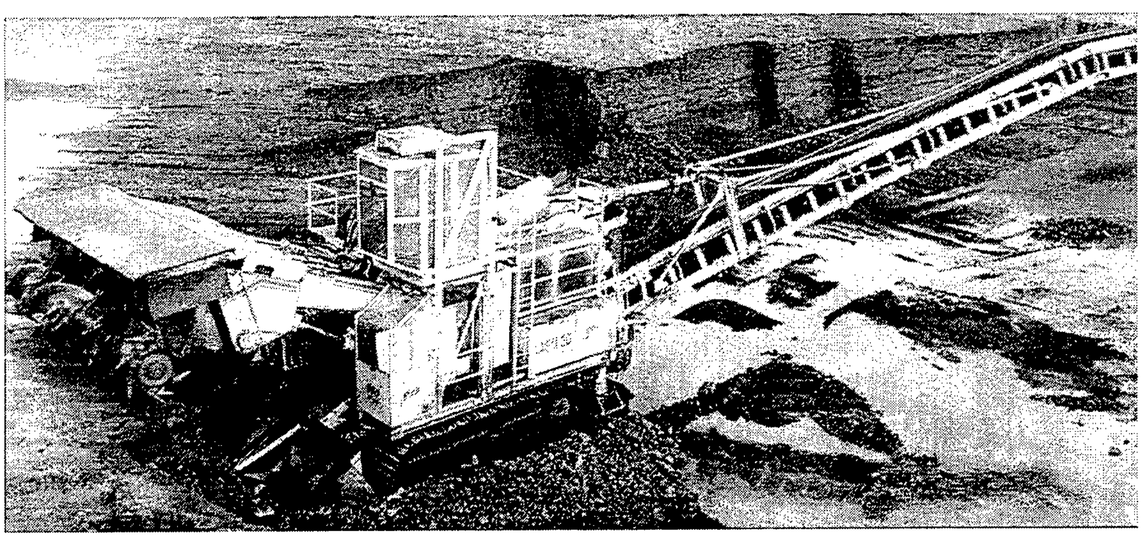

Figure 7 Voest-Alpine Surface miner

3 CRUSHING

Depending on the transportation method, the primary crushing is done either on the surface or in the pit. Traditionally the primary crusher has been beside the concentrator, but when for example conveying is used the material must be resized before transportation is possible.

The size, capacity and design of a pit determine if the crusher is fixed, semi-mobile or mobile. Large pits may have a fixed in-pit crusher but in a small, continuously changing pit, the in-pit crusher must be mobile. In the literature many kinds of divisions of in-pit crushers can be found. Possible names of the groups are mobile, semimobile, movable, portable, modular, semifixed and fixed crushers. Many names can be give to the groups, but three groups with any name divides the equipment by the idea of how and where they are used.

Fixed crushers (Figure 8) can be constructed to have higher capacity than a crusher which must move occasionally. As the production is over a large area, in-pit transportation is inevitable. The crusher is positioned beside the hoisting system to be a fixed part of the ore transportation to the surface.

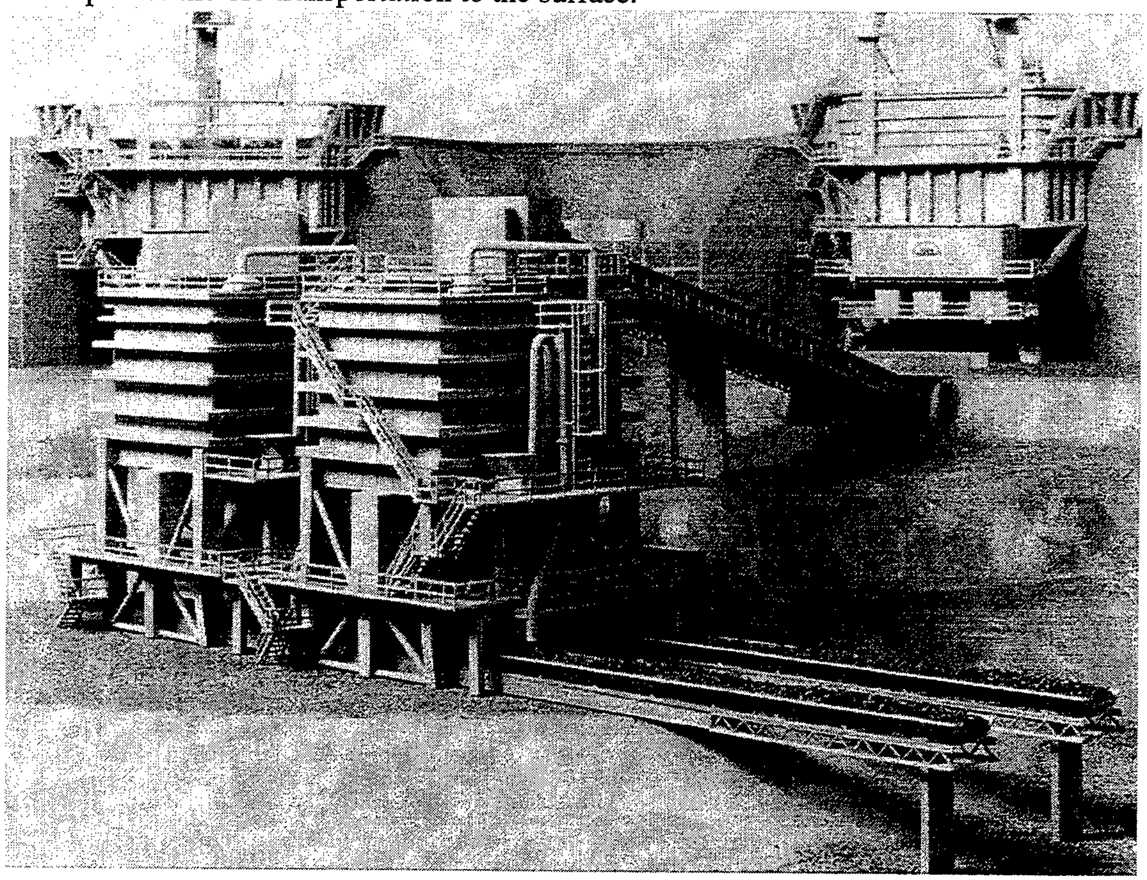

Figure 8 Fixed crusher plant (MAN TAKRAF)

Semi-mobile crushers (Figure 9) are used, where the capacity is so high that mobile crushers are too small, the area is large and production continues for a long time in the same place. In large open pits where production is on one level for a long time the in-pit crushers are erected as permanent crushers. The crusher is constructed so that moving is possible without making new bedding. Moving will occur only a few times in a year maximum. The semi-mobile crushers are equipped with skids, crawler carrier, or wheels for relocationing, and in heavy construction, moving is done with crawlers or a walking mechanism. Rail wheels should be considered for extremely heavy crushers because of the greater efficiency (low rolling friction).

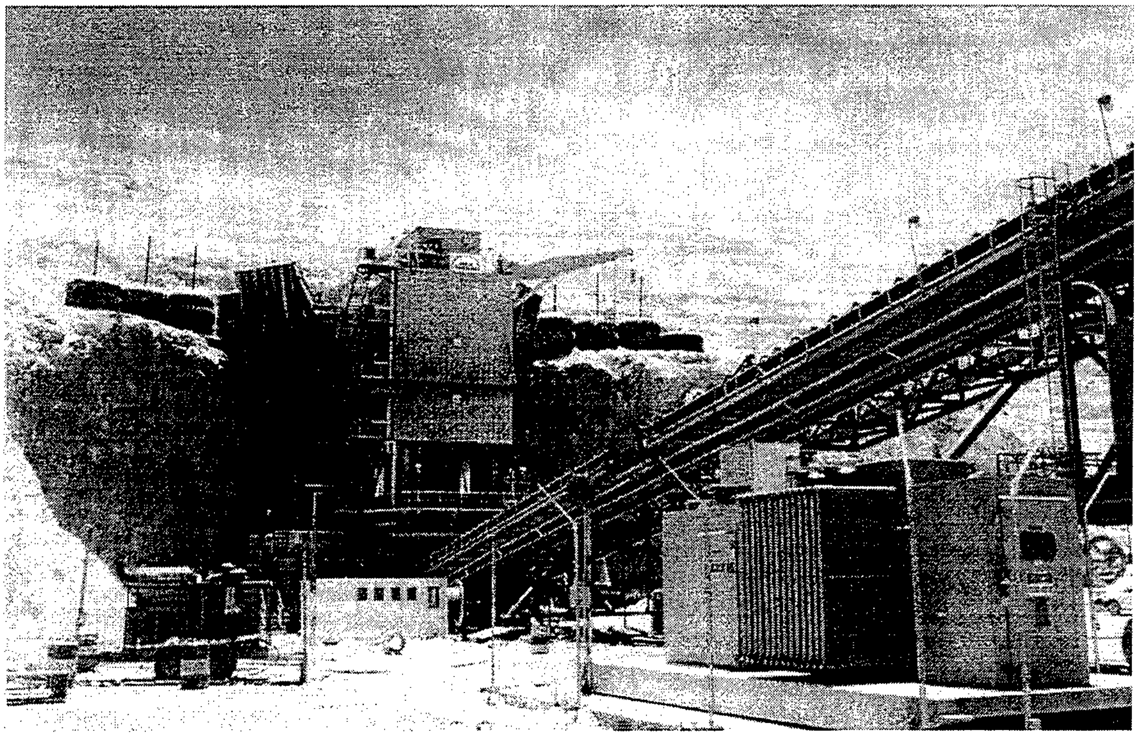

Figure 9 Semi-mobile crusher.

Mobile crushers (Figure 10) are used in small pits or in pits where the area of production is moving continuously. The crusher is mounted on a crawler carrier and it is driven to the mine face to be directly fed by the excavator. The crusher moves together with the excavator, as the mining progresses.

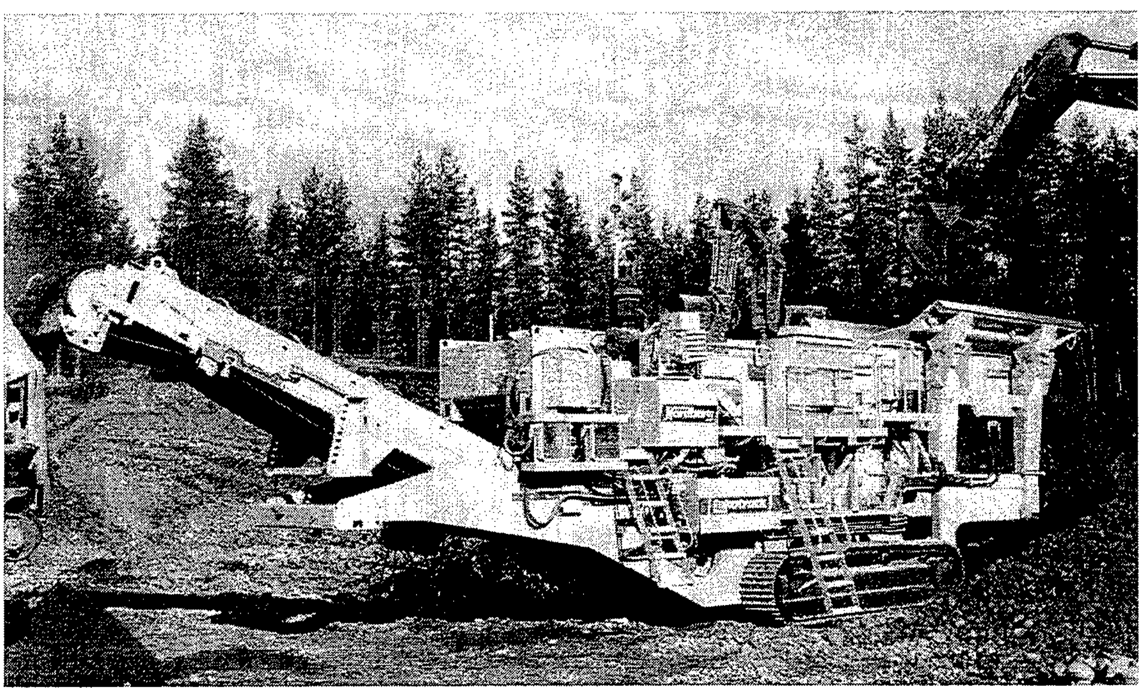

Figure 10 Mobile crusher.

4 TRANSPORTATION METHODS

4.1 Trucks

The trucks used in open pits are typically off-highway-trucks. The most used type in Finland is the conventional rear dump truck (Figure 11). These kinds of trucks are capable of hauling almost any kind of material. Trucks are powered by diesel engines with either mechanical or electrical wheel drives. Typical capacities for these are up to 130 tons for mechanical drives and up to 350 tons for electrical drives.

The trucks are very versatile, being capable of transporting a wide variety of materials. The usability is good, also in bad road conditions because the weight distribution is favorable and turning circle is small. The right truck size can be selected from an assortment of capacities up to 350 tons.

The truck hoisting system is quite dependable, as there is usually more than one piece of equipment in use. If one truck breaks down there is still capacity in other trucks to operate the transportation.

Compared to other hoisting systems, truck hoisting investment costs are quite low but the operating costs are much higher than for example in conveying. Truck hoisting operating costs are mainly fuel and labor costs which vary a lot from country to country. The next step in the fight against the high operating costs is tele-operated or remote controlled trucks. In the future there will be even bigger trucks which can be the solution to lowering the operating costs in some mines.

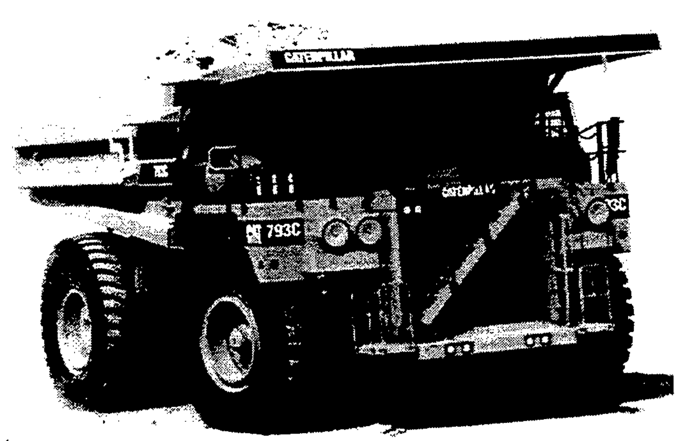

Figure 11 A typical rigid frame truck with capacity over 200 tonnes /4/.

4.1.1 Truck cycle time

Truck cycle time is the time required to complete one cycle of operation. One cycle includes: spot and load, haul load, spot and dump and return empty. Total cycle time also includes waiting times and delays.

The productivity of a truck is dependent on average payload and average cycle time. Matching a loader and truck and appropriate number of pieces of equipment with correct capacity is therefore essential for optimal productivity.

Each phase of the cycle is affected by many parameters. These are collected to Table 2.

Table 2 Effects on cycle time

Cycle phase	Term of effect
Spot and load	Method of spotting and loading
	Size of a spotting and loading area
	Equipment size and maneuverability
Haul	Haul road layout and design
	Grade, length, curves, velocity limits
	Driver skill and attitude
	Road and equipment maintenance
Spot and dump	Space and ground conditions
	Supporting equipment
All	Weather and climate conditions
	Matching of equipment
	Number of pieces of equipment
	Capacity

4.1.2 Articulated haulers

Articulated haulers can handle terrain that may not be well-suited for standard rigid-frame haulers, such as soft, slippery and twisted terrain. The capacity of an articulated hauler is up to 40 t compared to conventional rear dump trucks which can handle loads up to 350 t. They are also susceptible to boulder size and high-impact loading and are therefore mostly used in smaller quarries /5/ and for removing overburden (Figure 12).

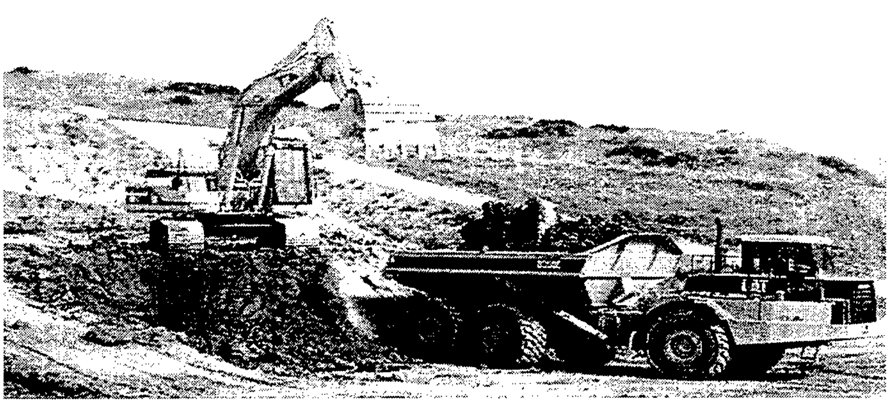

Figure 12 Articulated trucks can handle more difficult terrain than rigid frame trucks /6/.

4.1.3 Bottom dump haulers

The bottom dump haulers are mostly used in coal hauling with long hauling distances and low gradients.

The main advantage of these vehicles is that they offer high capacity with low truck loading heights, thus allowing a great number of loading options. Another advantage is the greater power efficiency, because of not so rugged construction as rear dump trucks.

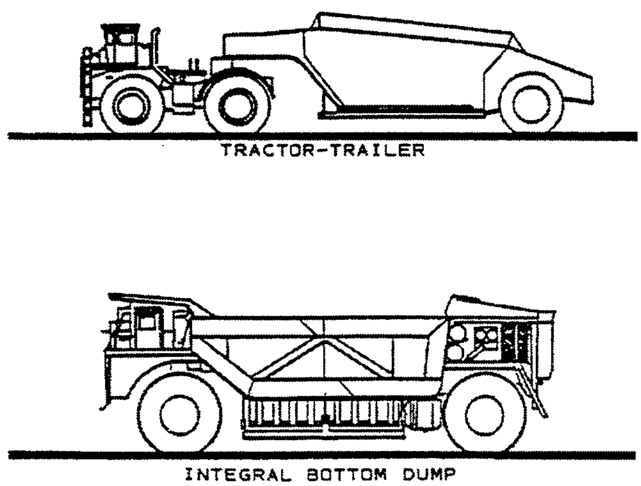

Figure 13 Typical bottom dump haulers.

An analysis has been undertaken, which suggests that for a less than 10 km haul distance the conventional rear dump haulers would probably be the best choice, whereas over that haul distance, bottom dump haulers are the best choice. /7/

The disadvantages of bottom dump haulers are the higher demands of road condition, difficulty in handling steeper grades and larger turning circles. These criteria prevent their use in many open pits.

Table 3 Comparing the options /7/

	Dump cycle [seconds]	Top speed [km/h]	Gradeability	Net-to-tare
Unitised two-axle	<15	80-	limited	2.0 -
Three-axle tractor/trailer	<15	50-60	very limited	1.5 -
Two-axle, rear dump with combination body	90-180	50-60	good	1.3 -

4.1.4 Trolley assisted trucks

There are specific conditions which favor the use of trolley assisted trucks. These are long ramps which do not need frequent relocations as well as operations where the cost of diesel fuel is high compared to electric energy.

The feasibility of a trolley system is questionable in many cases, because of the requirements of the pit and high investment costs. Introduction of trolley assisted transportation requires at least the following installation:

1. a suitable electric power distribution system,
2. the trolley wire line ramps and
3. modification to the electrical systems of the individual trucks.

In suitable pit conditions at least the following benefits are achieved with the trolley system:

1. truck fleet productivity is higher (higher speed on ramps)
2. lower operating costs

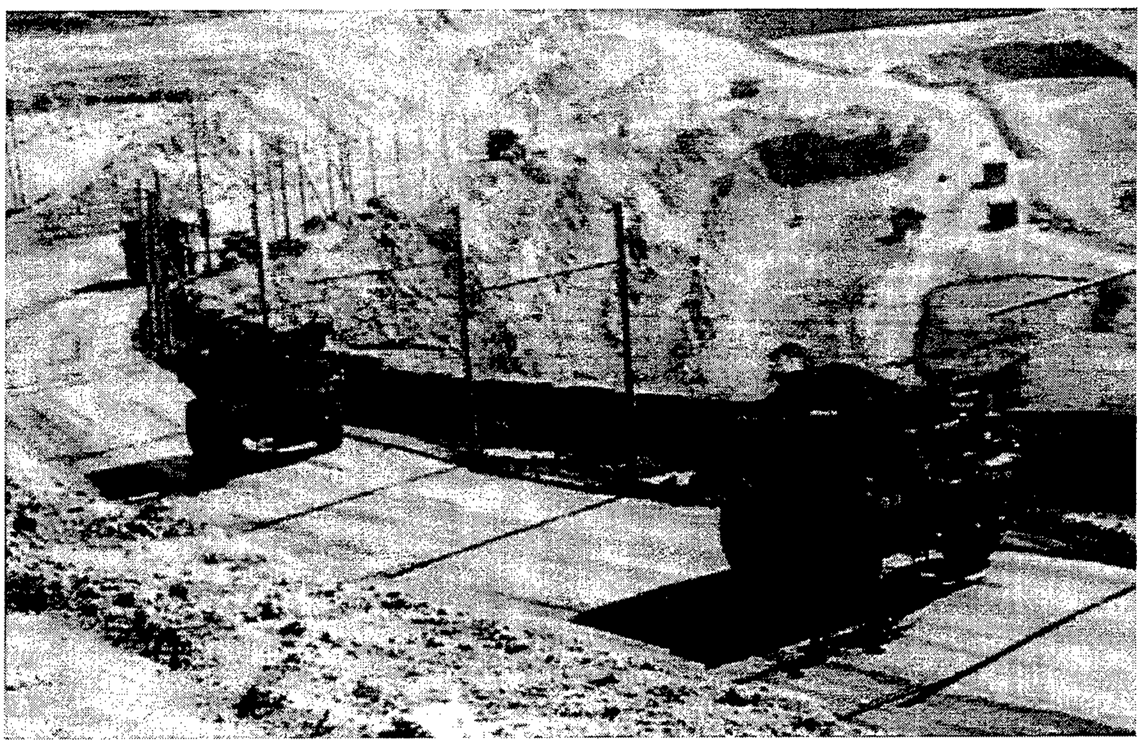

Figure 14 Trolley assist boosts uphill hauling speed and cuts operating costs.

4.2 Conveying

Belt conveying has been one of the most economical ways to move bulk material up to several kilometers. The increasing prices of fuel and labor have made conveying even more economical. The development of equipment has made conveying construction more versatile, allowing horizontal curves and higher conveying angles (even vertical).

Belt conveying in the area of open pit mining business can be divided into three phases:
1. in-pit conveying
2. in-plant conveying
3. overland conveying

In this paper the focus is on in-pit conveying and conveying material to the concentrator. In-plant and overland conveying can be mentioned in passing by saying that overland conveyors are used successfully at distances up to 50 km and that the speed of in-plant conveyors is typically lower than overland conveyors to reduce dust pollution.

Several types of conveyors are available for specific applications. Although more than one type of conveyor may solve the particular material transportation problem, an optimized installation is the result of careful planning. Some conveyor types like cable conveyors are economical only for long distances and therefore are not discussed in this paper.

Many types of construction have been developed in addition to the classic conveying, e.g. shiftable, crawler-mounted, mobile, sidewall, sandwich and high angle (HAC) conveyors. These adaptions stand for two categories: moveable conveyors (first three) and high angle (last three) conveyors.

The basic idea in these construction types is that moveable conveyors can be shifted to a better position and high angle conveyors do not take so much space when erected to the sidewall.

4.2.1 Classic conveying

Conveyors are used to transport a wide range of bulk materials. The requirements for material size in conveying are stricter than for many other transportation methods. In the mining business the extraction method determines the particle size. In many cases the particle size must be reduced by crushing to be suitable for conveying.

The basic design parameters for conveyors are: material density, edge distance and percent loading, belt speed, lump size and size distribution, surcharge angle of material troughing angle and length of individual rolls and belt inclination. These parameters affect the capacity of a conveyor which is calculated according to the normal cross-sectional area of the belt and belt speed.

$$Q = A \times V \times 3600 \qquad \text{Eq. 4-1}$$

where
Q= capacity [t/h]
A= cross-sectional area [m^2]
V= belt speed [m/s]

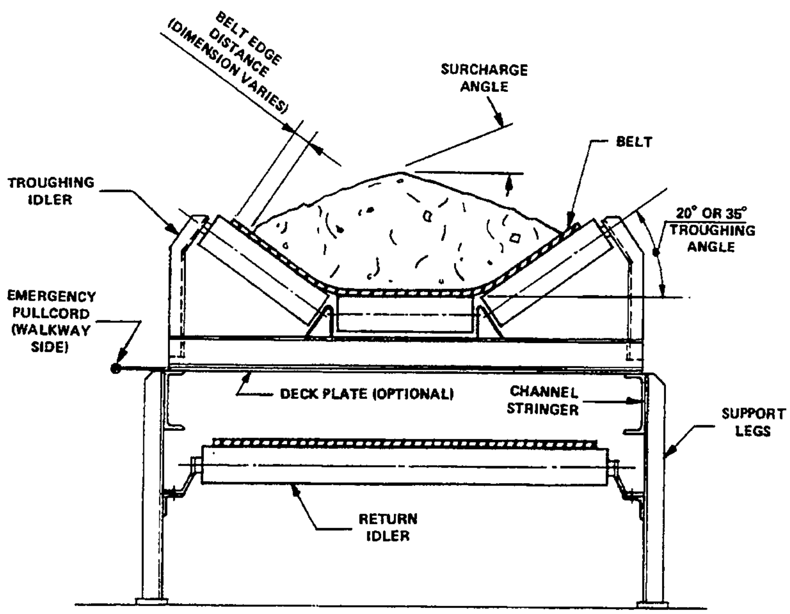

Figure 15 Nomenclature of a conveyor /8/.

Classic conveyors are used in places where the installation can be "permanent", e.g. in hoisting tunnels or in the main ramps which stay untouched for a long time. The advantage compared to truck hoisting is that the ramps can be narrower, and the maintenance costs for the ramps are a lot lower.

4.2.2 High angle conveying

The classic conveyors suffer from a lack of flexibility. The installations are quite permanent which makes it difficult to change plans quickly. The hoisting tunnels do not affect plans for ramps and daily production but they still determine the major parameters for pit planning.

High angle conveying is one answer to the problem of high installation costs and a large amount of preliminary work. No ramps are needed because the belt goes straight up over the wall (Figure 16).

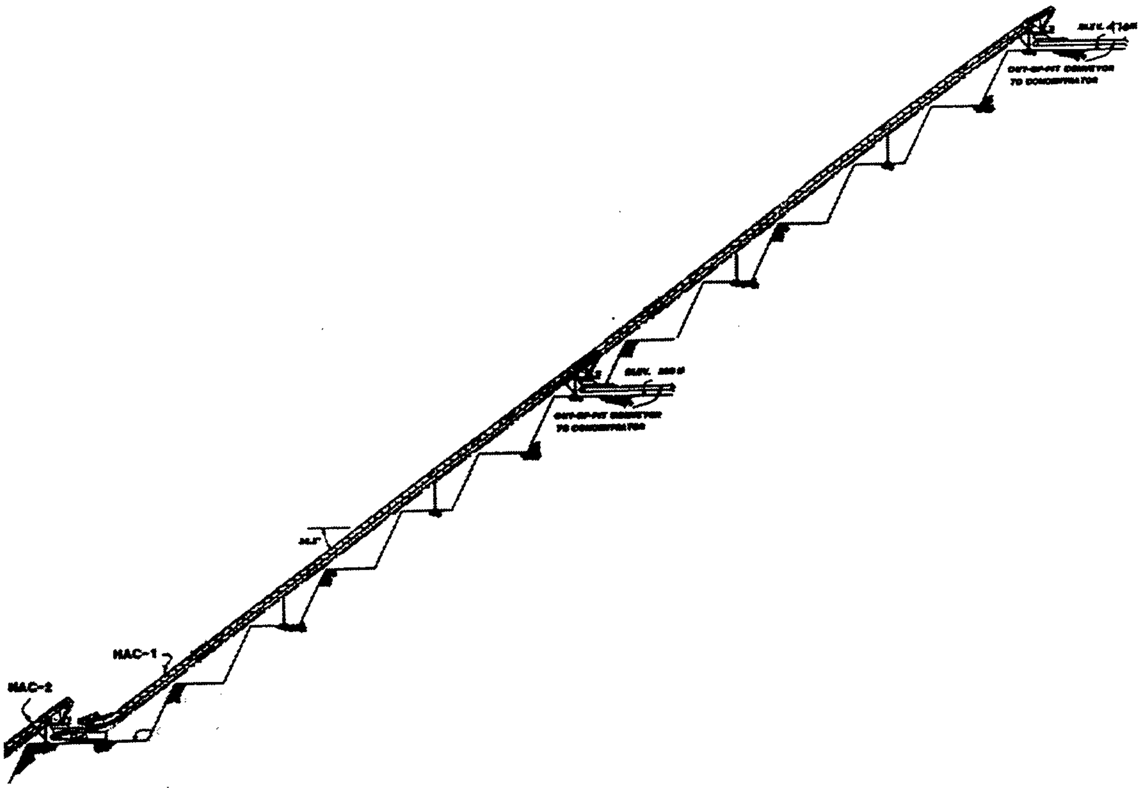

Figure 16 HAC at the Majdanpec copper mine

Several construction possibilities have been developed for high angle conveying, e.g. cleat/sidewall (Figure 17) and sandwich (Figure 18) conveyors.

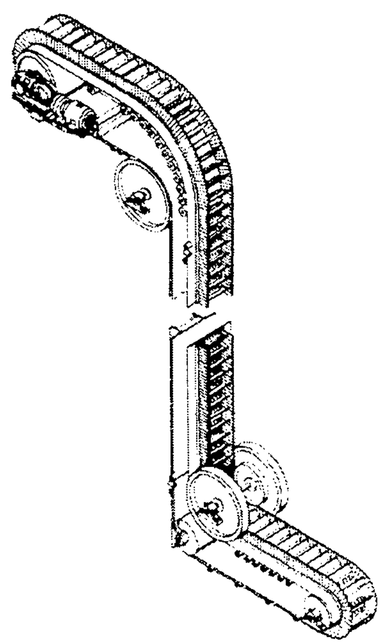

Figure 17 Sidewall conveyor /8/. *Figure 18 Sandwitch conveyor /9/*

In the cleat/sidewall conveyor there are cleats and sidewalls attached to a flat belt. These allow the elevation of many kinds of materials vertically. The sidewalls are pleated providing an accordion effect around pulleys. The particle size and material density are the most important limiting factors in the use of this kind of conveyor.

The HAC (High Angle Conveyor) is an example of a sandwich conveyor. The idea is to sandwich the material between the loaded bottom belt and covering top belt. During the transportation, the belts are not separated until the discharge area is reached.

The HAC system has been used in the Majdenpek copper mine since 1992. The conveying angle is 35° and the elevating height is about 100 meters.

4.3 Ore passes

Ore passes are raises, located at the bottom of the pit, which can be vertical or inclined. The cross section of a raise (ore pass) is round or rectangular, typically 1 to 16 m^2 in size. In some cases raises are lined to prevent enlargement of the cross sectional area. In addition to the use as a pass for ore, ore passes have storage capacity, which can be used to smooth the material flow to the concentrator.

The ideal case for ore pass material transport is a construction where the conveying system is in an adit at the level below the ore deposit (Figure 19).

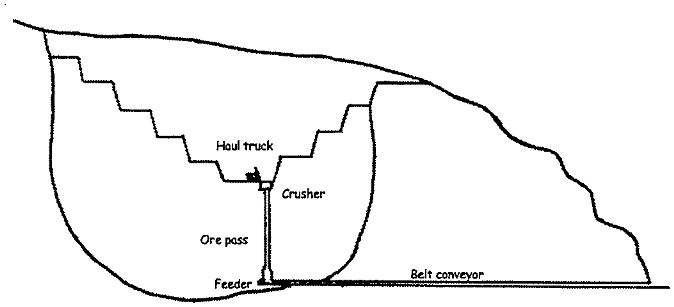

Figure 19 An ideal case for an ore pass.

The second case suitable for ore passes is a deep deposit, where at a certain level the ore pass compares favorably with the cost of other transportation systems (Figure 20).

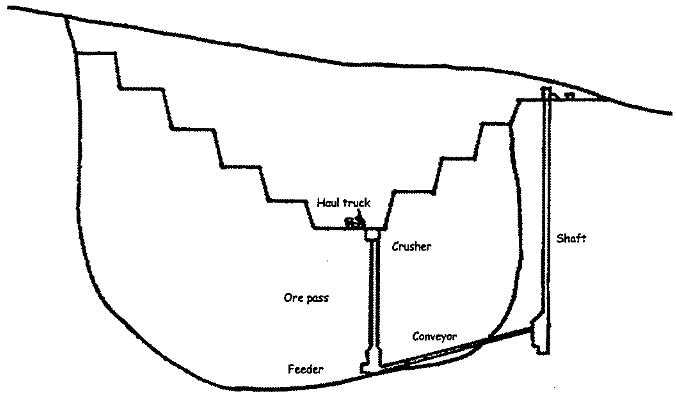

Figure 20 Ore pass in deep deposit.

The third possible situation for the ore pass system is combination of open pit and underground mining (Figure 21). This requires underground operation beside the open pit mining, otherwise fixed costs are too high to be economical.

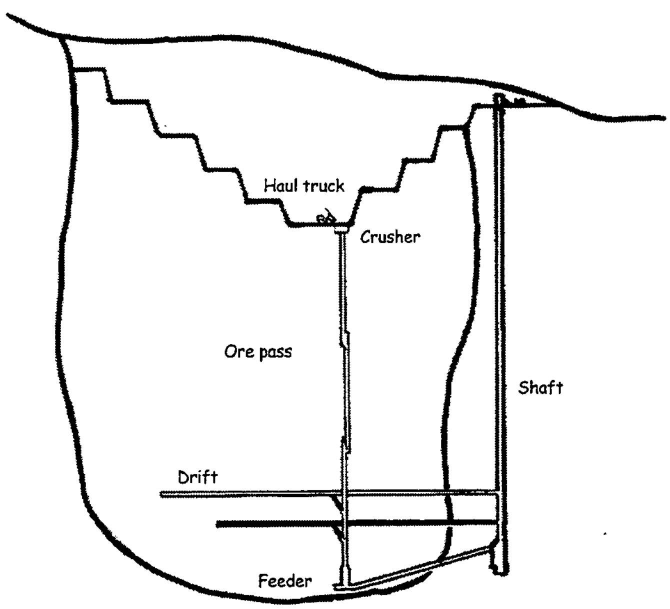

Figure 21 Combination of open pit and underground mining.

All the previous cases have a vertical ore pass, which is not the only alternative – the ore pass can also be inclined (Figure 22). There are several pros and cons which should all be noted when designing the ore pass. First comes the costs: a vertical ore pass is shorter for the same elevation difference than the inclined ore pass and it is cheaper, faster and more accurate to construct. On the other hand, the horizontal component of an inclined ore pass replaces the horizontal transportation methods and tunnels needed for that purpose, which lowers the total costs. In a vertical ore pass there is more autogenic crushing, which can be a good or bad thing. Vertical ore passes are more easily slashed to increase storage capacity but they also are more easily arched.

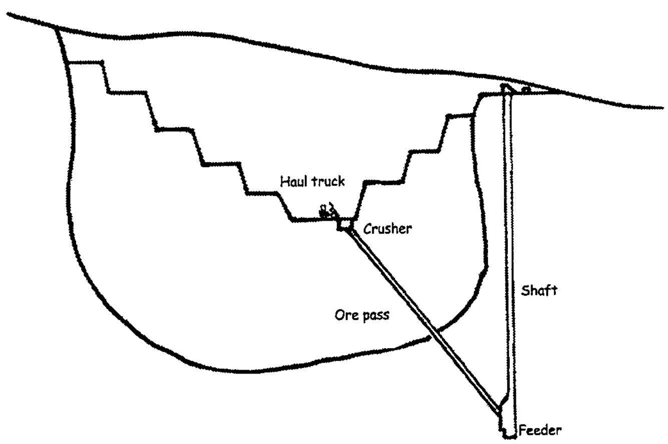

Figure 22 Inclined ore pass.

Ore passes can be constructed in many ways but nowadays raise-boring is the most common. It has many advantages such as: it is faster, less costly, less hazardous for miners and produces a smoother wall than blasting.

4.4 Other methods

The methods described in the previous chapters are widely used and accepted as universal alternatives. There are still methods which are used in special cases and methods which are under development which may some day become true competitors with current methods. For example crane hoisting and hydraulic hoisting are those kinds of methods. They have been widely studied for many years but have not yet become popular.

4.4.1 Crane hoisting

Crane hoisting is a new solution for open pit mining and some deposits have been exploited using this method /10/. The idea of the method is to eliminate the waste mining as much as possible. In pits designed for crane hoisting all necessary equipment, mined ore and waste, and workers are transported by crane. Even when using a standard crane and other standard mining equipment, the results have been encouraging.

The main advantages are the small amount of waste which needs to be mined and the flexibility of the method. The capacity of the method is compatible with other hoisting methods.

The hoisting method determines the mining method and equipment to be used. Normal mining methods can be used but today there is no specially designed equipment and standard equipment must be used. The important considerations for development of this crane hoisting method are the design of the skip for ore hoisting, adding teleoperation or remote control possibilities for crane and other equipment and development of machines suitable for both production drilling and pit wall bolting, to make the competitiveness of this method even better.

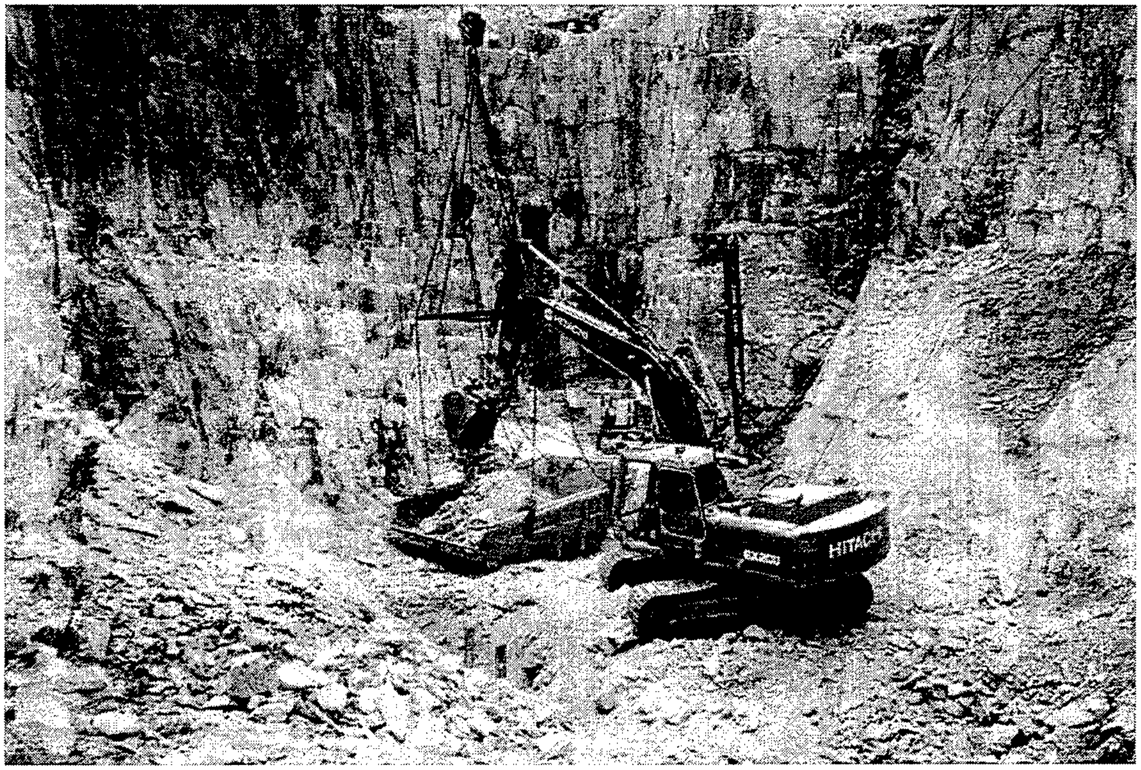

Figure 23 Loading from a vertical slope pit /10/.

The bench angle must be almost vertical to have access to the bottom of the pit. Rock support and the measuring of the displacements are needed to keep the pit safe.

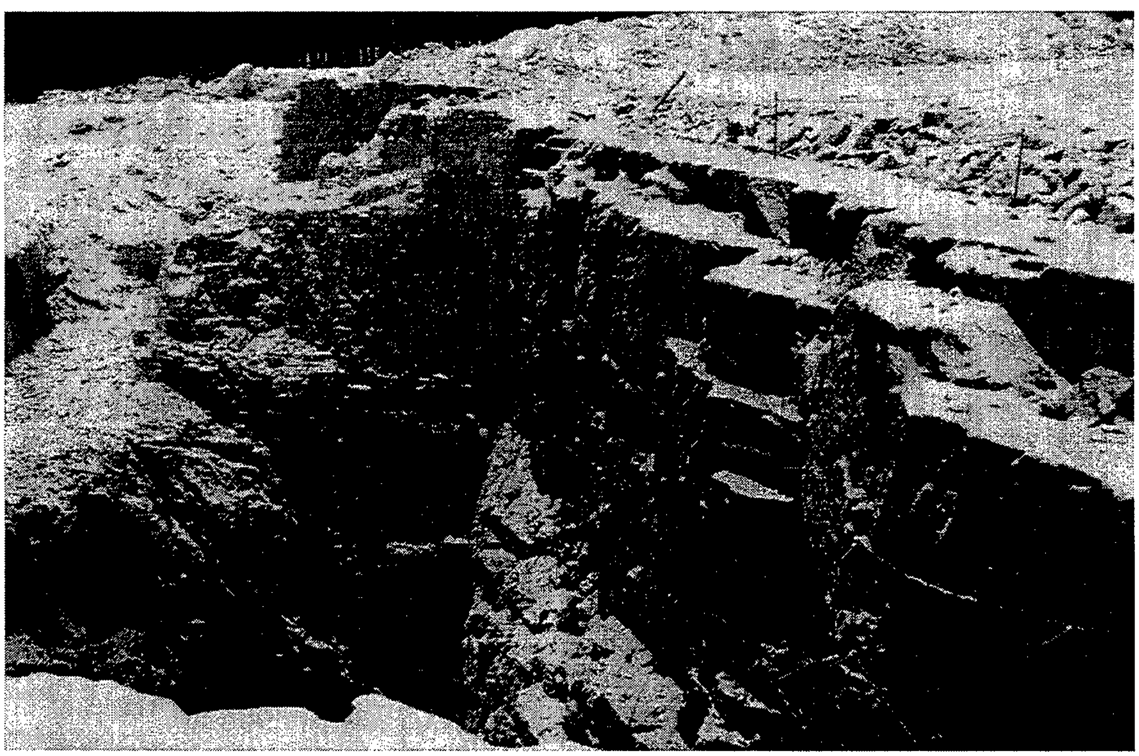

Figure 24 Installed bolts and straps.

4.4.2 Hydraulic hoisting

Hydraulic hoisting has been much studied for underground mining cases. Hydraulic transportation was used the first time in 1914 for coal transportation but serious research on the subject was started in the 1950's. Since then hydraulic transportation has been used to move many kinds of materials (coal, nickel concentrate, limestone, bauxite, gold ore etc.).

There are working examples in the world of hydraulic transportation up to 1000m elevation and a horizontal transportation up to 35 kilometers, mainly in underground mines /11/. Still, hydraulic hoisting has seldom been the only hoisting method in metal mines.

In Finland, where winters are cold, water as a medium can cause problems. In cold winters the mined ore may be -30°C which freezes the medium if water is used. Heating must be used, but that raises the hoisting costs. A combination of ore pass and hydraulic hoisting may solve that problem.

The suitable particle size, technically and economically, for most materials is <5 mm. Larger particles have been used only in coal transportation.

5 DISCUSSION

Open pit transportation may constitute up to 50% of total operating costs. This means that even small improvements in material transportation has a big effect on the economy of the pit. Therefore, it is important to carefully calculate the most economical transportation method for the specific case.

It is evident that sensible cost functions for open pit transportation cannot be calculated, because there are a lot of parameters which vary greatly from case to case. Each case must be checked separately with its own parameter values. Similarly, the transportation methods vary so much from pit to pit that universal comparison can not be made.

The direction of ore production is heading towards more continuous methods. The continuous method, like high angle conveying, with many different variations, is a good alternative to traditional truck hoisting. The best way of erection depends on the pit layout, but many alternatives are available. Another interesting ore transportation method for continuous open pit mining is hydraulic hoisting. If the material is already fragmented to small particles due to the extraction method, the needed particle size is easily reached. Because of cold seasons, if water is used as a medium, heating and insulation are needed to avoid freezing problems.

6 CONCLUSION

Continuous production is the term of today. In the mining business, continuous mining methods are commonly used in soft rock. With new technology, harder and harder rocks can be cut, and continuous methods can be applied in hard rock pits too. With the use of continuous hoisting methods like conveying, the whole production line can be built to be continuous.

In many cases in Finland, continuous extraction can not be used, because of the hard rock, and the traditional drill-and-blast-method must be used. This doesn't mean that there are limitations to choosing the hoisting method. With in-pit crushing, all transportation methods are available if needed particle size is suitable for the concentrator and the continuing processes.

The ore transportation method can rarely be changed during the pit production. Large investments have been made, which dictate the limits of ore production, or at least raise the total investment costs when left unused. Therefore, in the beginning of the mining project it is important to carefully calculate the economic alternatives for ore transportation.

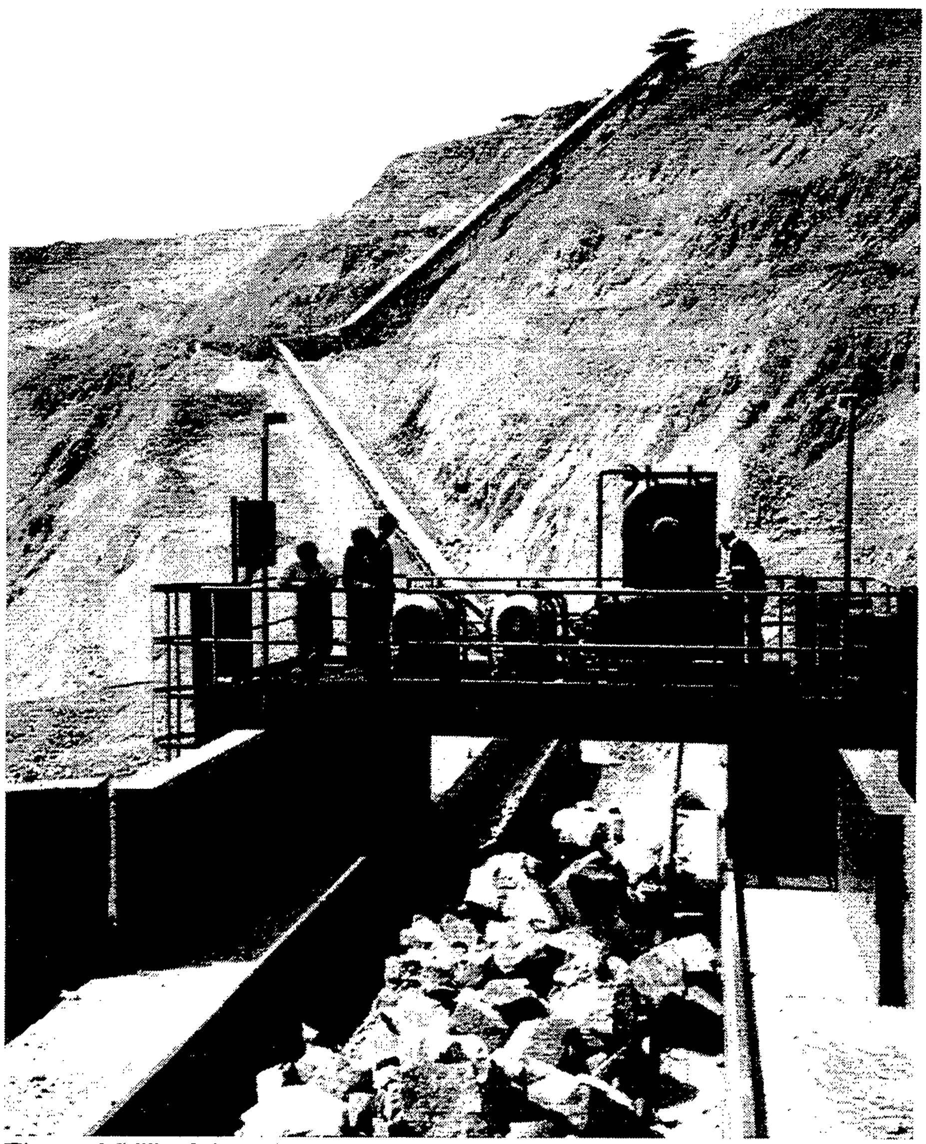

Figure 25 HAC installed in Majdanpec /12/.

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Open pit mining, Extraction and ore transportation methods

Abstract

Open pit transportation has an important role in the open pit mining business. In some cases, the transportation has a 50% slice of total operating costs. Therefore, it is important to carefully calculate the most economic transportation method for the specific case.

The ore transportation method can rarely be changed during the pit production. Large investments have been made which dictate the limits of ore production, or at least raise the total investment costs when left unused. Therefore, in the beginning of the mining project it is important to carefully calculate the economic alternatives for ore transportation.

The aim of this report is to collect the main the aspects of ore transportation methods suitable for Finnish mines. The pros and cons of the methods depend a lot on the particular case and its features. In some cases typical advantages may change to problems and on the other hand big problems may be eliminated with a certain method. For example hydraulic hoisting (if water is used as medium) may be a good choice in places where the ground water is problem, because the water is hoisted with the ore.

Cost comparison is left outside this report, for the following reasons: a) because of numerous parameters affecting the real cost of a particular method, the given cost would be correct only in one sample case b) not even average cost figures were available in many methods and c) even if they were, the trendsetting numbers may give a misleading idea of costs in different cases.

Keywords

transportation, hoisting, open pit mining

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Open pit mining, Extraction and ore transportation methods

Tiivistelmä

Kiven kuljetus voi muodostaa jopa 50% avolouhoksen käyttökuluista. Tämän vuoksi on esiarvoisen tärkeää selvittää kulloisiinkin olosuhteisiin parhaiten sopiva menetelmä.

Monestikaan ei ole mahdollista vaihtaa nostomenetelmää toiseen tehtyjen investointien takia, tai ainakin jo tehdyt investoinnit nostavat kokonaisinvestointikustannuksia vanhojen laitteiden jäädessä käyttämättä. Tästä syystä on tärkeää kiinnittää jo suunnitteluvaiheessa riittävästi huomiota myös nostomenetelmän valintaan. Nykyisin monilla kaivoksilla noston suorittaa itsenäinen urakoitsija, jolloin sopimuksen umpeutuessa on hyvä tarkistaa tilanne myös menetelmän osalta.

Tämä raportin ensisijaisena tarkoituksena on ollut kerätä pääkohdat Suomessa kyseeseen tulevista malmin nostomenetelmistä. Menetelmien edut ja haitat riippuvat hyvin paljon kohteesta ja sen erityispiirteistä. Joissakin paikoissa yleisesti selkeät edut voivat muuttua haitoiksi ja toisaalta suuret haitat voidaan eliminoida jollakin toisella nostomenetelmällä. Esimerkkinä voi mainita hydraulisen noston (mikäli käytetään nostossa väliaineena vettä), joka runsasvetisissä kohteissa voi olla hyvinkin edullinen vaihtoehto, koska malmin kanssa samalla saadaan nostettua muuten haitallinen vesi.

Kustannusvertailu on jätetty kokonaan pois seuraavista syistä: a) koska todellisiin kustannuksiin vaikuttaa suunnaton määrä parametreja, olisivat annetut kustannukset oikeita vain tietyssä esimerkkikohteessa, b) monista menetelmistä ei ollut saatavilla edes keskimääräisiä kustannuksia ja c) suuntaa-antavienkin lukujen antaminen on katsottu voivan antaa harhaanjohtavan käsityksen todellisista kustannuksista eri kohteissa.

Avainsanat
nosto, kuljetus, avolouhos, avolouhinta

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